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Laboratory Research on Airglow Excitation Mechanisms Using Atomic Beam Techniques

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Present Status:

During the first six months of work under this grant the major activity has been the construction of the basic modulated atomic beam machine which will be used to study the chemical reactions postulated to account for the airglow. At this point the three diffusion-pumped chambers are mounted and plumbed in for differential pumping in the required combinations. The control and interlock circuitry for the vacuum system are virtually complete, the circuitry for the quadrupole mass filter detector is completed and the electronics for 1440 cps current measurements is in hand. Currently the tubular furnace source for H and O atoms and its controls are being constructed and the modulation innards (i.e., chopper motor and wheel, reference signal pick-up, etc.) are being assembled and installed.

The fourth chamber of the system, which will be liquid helium pumped and which will be suspended into the third chamber, is being designed. This is really the crucial part of the machine since it is the element which is responsible for terminating and trapping the cross beam, which if not exceedingly well trapped allows gas from the cross beam to return to the vacuum and cause noise in an electron-impact ionization detector.

Also being designed at present is the double oven which will be used to make beams of sodium and which we want to try for producing beams of NaO for certain of the experiments.

Future Plans:

The plans for the immediate future are to complete construction of the machine and then to initiate the experiments. Generally the experiments will follow the course outlined in our proposal, although some inversion of order seems appropriate. In particular, the reactions leading to excitation of sodium light appear to be the most enchanting at the moment, particularly the reactions $Na + O_3 \rightarrow NaO + O_2$ and $NaO + O \rightarrow Na^* + O_2$, along with $NaO + H \rightarrow Na^* + OH$, and we expect to concentrate on these reactions first. The reasons are partly to provide information for interpretation of rocket experiments of Prof. Donahue, to provide incidentally some information relevant to some re-entry questions of interest to ballistic missile defense (of which we have only recently learned) and because with sodium the prognosis for success of the experiments is unusually high due to being able to use highly efficient surface ionization detectors and also the D-line light to detect some of the reactions. Recent conversations with W. Klemperer of Harvard, who has done rf spectroscopy of NaO, lead us to believe that by using an oven in which sodium and NO_2 (at an overpressure) are placed the prospects are good for producing a beam sufficiently rich in NaO to successfully study the second and third reactions above. Klemperer's use of an inhomogeneous electric field to separate Na from NaO also represents an experimental tool in dealing with the sodium reactions of which we were previously unaware. Such separability adds redundancy to the other experimental techniques available for the reactions and further increases the prognosis for success of the experiments, particularly for the $Na + O_3$ reaction.

Personnel:

Personnel who have been engaged in the work from its inception have been Professor W. L. Fite, Professor R. T. Brackmann and Mr. H. Lo. At the beginning of November, we were joined by Dr. J. E. Mentall who came from the University of Western Ontario in Canada, who will be engaged full time in this research.